

SCIENCE FOR CERAMIC PRODUCTION

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EFFECT OF THE SHAPE OF MONOSIZE ELECTROCORUNDUM POWDER PARTICLES ON THE PHYSICAL – MECHANICAL PROPERTIES OF POROUS PERMEABLE CERAMIC SAMPLES

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The physical – mechanical characteristics of powders of monosize electrofused corundum with fraction F240, produce by “RUSAL Boksitogorsk” JSC (Russia) and F240 Alodur WSK, ZWSK, and SWSK produced by Traibacher Schleifmittel (Austria) are determined. The effect of the shape of grains in the electrofused corundum on the open porosity, permeability, and ultimate strength of the porous permeable ceramic is studied. The quantitative interrelation between the ultimate strengths under normal, diametral compression and bending of samples of porous permeable ceramic made from the electrocorundum powders is determined.

Key words: porous ceramic, electrocorundum, monosize powders, permeability, ultimate strength, grains, shape.

Porous permeable ceramic materials made from monosize powders possess a number of advantages over the same materials made of metals, glass, and plastic. They are stronger, stable in acids and alkali, melts of ferrous and non-ferrous metals, and corrosive slags. They can be used in a range of temperatures.

These materials can be divided into several groups by areas of application:

filtering ceramic materials whose operation is characterized by the presence of excess pressure of a gas or fluid flowing along pore channels, can be cleaned, homogenized, separated, and mixed together; filtering elements for removing dust or water and oil mist from air, as well as air and hot corrosive gases, for example, blast and Martin furnaces, at temperatures to 1000°C; filtering elements for removing aerosols, including radioactive aerosols, from gases; filtering elements for purifying drinking water and sewage from industrial enterprises, solutions of electrolytes, pulps, salt solutions, wine, milk, acids, alkali, melts of ferrous and nonferrous metals; dispensers for finely dispersed spraying of gases into liquids or melts, as well as gases reagents in chemical reactors in order to increase the contact surface area [1 – 3];

capillary-porous ceramic materials, whose operation is based on the use of capillary pressure arising at a liquid – gas – evaporator interface, wicks in heat pipes, capillary pumps, hydraulic gates, and so forth (Japan Patent No. 54-95611);

porous ceramic materials with special properties, for which interaction of pore surface with a phase introduced beforehand or passed along pore channels in the course of operation, which intensifies the physical and chemical processes — membranes for reference electrodes, substitute for bone tissue, and others [4, 5].

It can be concluded from the data presented on the areas of application of porous ceramic materials made of monosize powders that articles made of such materials can have different geometric shapes (one- and multichannel tubes, hollow cylinders, plates, and so forth) and dimensions and can operate in contact with various corrosive media, at high temperatures, and under compression, bending, and other loads. In this connection it is important to investigate the physical – technical and, in particular, the strength characteristics of porous permeable ceramic materials under normal compression (below — simply compression), diametral compression, and bending, since knowledge of these characteristics will make possible purposeful selection of materials for concrete operating conditions.

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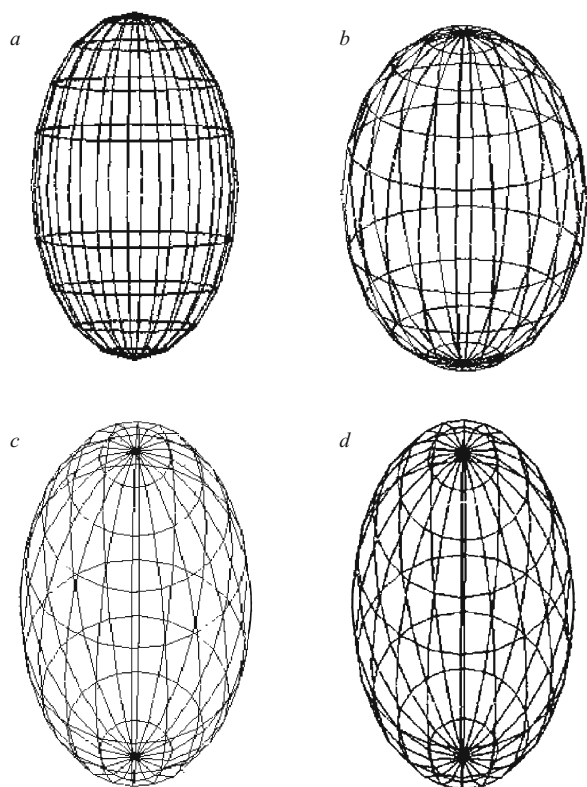


Fig. 1. Shape factor of electrofused corundum powder: *a*) F240, particle shape factor 1.390; *b*) F240 Alodur WSK, particle shape factor 1.441; *c*) F240 Alodur ZWSK, particle shape factor 3.222; *d*) F240 Alodur ZWSK, particle shape factor 4.478.

The purpose of the present work is to investigate the effect of the grain shape of monosize electrocorundum powder on the physical – technical properties of porous permeable ceramic.

Powders of electrofused corundum of F240 fraction, produced by the “RUSAL Boksitogorsk” JSC (Russia) and F240 Alodur WSK, ZWSK, and SWSK produced by the Traibacher Schleifmittel Company (Austria) were used as the monosize filler for fabricating porous permeable ceramic.

The particle size distribution for electrocorundum and the shape factor were measured with a Analyzette 22 laser particle analyzer from the Frutsh GmbH Company (Germany). The microstructure of the powders was studied with a JSM-6490 LV scanning electron microscope from the JEOL Company (Japan).

The physical-technical properties of the electrocorundum powders were determined in accordance with the state standards using the procedures approved at the “Bakor” Center for Science and Technology JSC: flowability of bulk materials and the angle of repose — MI 773998-14–2003, bulk density of powders — MI 11773998-7–2003. The specific surface area of the powders was measured by means of low-temperature adsorption of nitrogen using the Asap 2020 apparatus from the Micrometrics Company (USA).

TABLE 1.

Powder	Powder size distribution, μm		
	ds_3	ds_{50}	ds_{94}
F240	10.6	55.4	91.1
F240 Alodur WSK	7.8	54.6	89.4
F240 Alodur ZWSK	6.6	52.4	75.9
F240 Alodur SWSK	14.1	62.1	102.5

TABLE 2.

Powder	Particle specific surface area, m^2/g	Bulk density, g/cm^3	Powder flowability, g/sec	Angle of repose, deg
F240	0.2317	1.66	207	35
F240 Alodur WSK	0.2833	1.59	226	30
F240 Alodur ZWSK	0.2312	1.64	202	25
F240 Alodur SWSK	0.2607	1.52	197	35

* Measurement error $\pm 0.0025 \text{ m}^2/\text{g}$.

Electrocorundum powders from the Traibacher Schleifmittel Company, in contrast to the powders from “RUSAL Boksitogorsk” JSC, after separating the F240 fraction, undergo additional separation in order to obtain fractions of powders with a definite shape. The monosize corundum powder produced by “RUSAL Boksitogorsk” JSC consists of particles with different shapes. Its specific surface area, bulk density, and flowability are similar to that of F240 Alodur ZWSK powder. At the same time the presence of particles with difference shapes in the F240 powder has the effect that the angle of repose of this powder is greater than that of F240 Alodur ZWSK powder, which consists primarily of particles with a uniform “cubic” shape. The diversity of the characteristics of the initial monosize electrocorundum powders suggests that the physical – technical characteristics of the porous permeable ceramic made from these powders are also diverse.

The samples used to investigate the physical – technical properties of porous permeable ceramic were fabricated by semidry pressing with specific pressure 30 MPa. The composition of the porous permeable ceramic was (wt.%): 85 monosize electrocorundum powder; 15 technological

TABLE 3.

Powder	Open porosity, %	Gas permeability coefficient, μm^2
F240	41.0	2.0
F240 Alodur WSK	40.4	2.0
F240 Alodur ZWSK	39.5	1.9
F240 Alodur SWSK	42.0	2.5

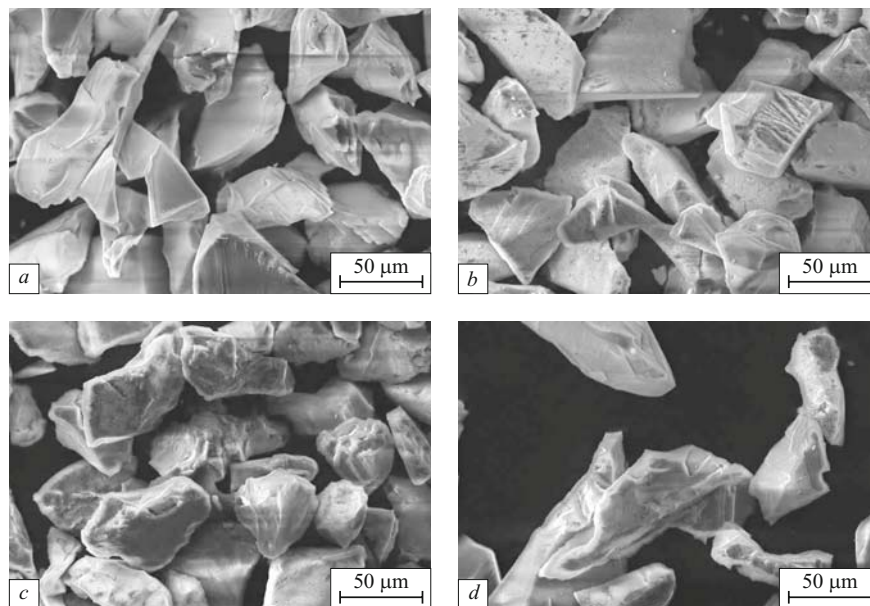


Fig. 2. Microstructure of monosize powders of electrofused corundum: a) F240; b) F240 Alodur WSK; c) F240 Alodur ZWSK; d) F240 Alodur SWSK.

binder — natural aluminosilicate — bentonite. The firing temperature was 1280°C, and the soaking time at maximum temperature was 2 h. The physical – technical properties of the porous permeable ceramic made of the monosize electrocorundum powders are presented in Table 3, and the dependence of the ultimate strength under compression, diametral compression, and bending of the samples of porous permeable ceramic on the shape of electrocorundum grains is presented in Table 4.

The post-firing physical – technical properties of the sample were determined by the following methods: apparent density and open porosity — MI 11773998-10-2003, gas permeability coefficient — MI 11773998-5-2007, ultimate strength under compression — MI 11773998-5-2003, ultimate strength under diametral compression — MI 11773998-15-2003, ultimate strength under bending — MI 11773998-3-2006.

The ultimate strength under compression was determined on cylindrical samples 36 mm high and 36 mm in diameter using an MO 2000 laboratory hydraulic press (Russia); the ultimate strength under diametral compression was determined on 15 mm high and 62 mm in diameter disks using a PSU 10 (Russia) laboratory hydraulic press; the ultimate strength under bending was determined for prismatic sam-

ples with dimension 16.6 × 15.6 × 105 mm using an Metefem XP-01 rupture machine (Hungary).

To determine the statistical distribution of the ultimate strength (within one batch of samples) under compression, diametral compression, and bending 25 samples for each type of test were prepared and tested. The confidence interval was ± 6.5 MPa for the ultimate strength under compression, ± 1.0 MPa for ultimate strength under diametral compression, and ± 2.4 MPa for ultimate strength under bending.

It can be concluded on the basis of the studies that monosize electrocorundum powder with different grain shapes used for fabricating porous permeable ceramic yields articles with different physical – technical and strength characteristics.

The powder F240 Alodur SWSK must be used to obtain articles with the maximum open porosity and gas permeability (for example, filtering elements for purifying gases).

Articles made of porous permeable ceramic, which are used under compression loads (for example, filtering elements of columnar filtering facilities) must be made of F240 powder, which imparts to the material the maximum ultimate strength under compression [6].

Porous permeable ceramic articles subjected to bending loads (for example, filtering elements for disk-shaped filtering facilities) should be made of monosize electrocorundum powder F240 Alodur SWSK [7].

TABLE 4.

Electrocorundum fraction	Ultimate strength, MPa		
	compression	diametral compression	bending
F240	82.1	16.4	35.7
F240 Alodur WSK	74.8	14.0	39.5
F240 Alodur ZWSK	56.4	13.8	41.6
F240 Alodur SWSK	67.0	14.5	43.0

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